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MEMORANDUM

To: Native Village of Tyonek
Tyonek, Alaska

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From: Joel Massmann, Ph.D., P.E.

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Subject: Chuitna Coal Project
Comments regarding groundwater flow modeling used to support the Preliminary Draft Supplemental Environmental Impact Statement

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This memorandum provides comments regarding the groundwater flow model used to support the Preliminary Draft Supplemental Environmental Impact Statement (PDSEIS) for the Chuitna Coal Project. The model is described in the August 2013 report prepared for PacRim Coal by Arcadis (Arcadis, 2013).

The model review summarized in this memorandum is incomplete because model input files have not been provided and were not reviewed.[1] These input files are necessary to complete an adequate and thorough review.

Examples of how model predictions are used

The authors of the PDSEIS point out that "*The groundwater model is the cornerstone of the groundwater quantity and flow analysis for the proposed project*." (Section 3.5.3.3.1). This is a reasonable representation of how the model is used to support the proposed

[1] Model input files are electronic files that are used to incorporate site-specific information into the computer code used to simulate groundwater flow. These model input files are typically developed using commercially-available software such as GWVistas. The model input files are somewhat analogous to a spreadsheet that is used as input to the Microsoft EXCEL software program or a text file that is used as input to the Microsoft WORD software program.

project. Ways in which model predictions are directly used in developing the PDSEIS include the following:

1. To predict impacts of the mining operations on groundwater discharge to streams.
2. To predict groundwater inflows to mining areas.
3. To predict pumping rates for groundwater dewatering wells.
4. To predict the timing and magnitude of water level changes in the vicinity of the mine.
5. To assess mitigation measures for impacts to stream flows.

Although not explicitly considered in the Arcadis report or the PDSEIS, the results of the groundwater modeling could also be instrumental in quantifying the potential effects of mining operations on surface water quality. An example would be estimating the water quality impacts if mitigation of baseflow reductions is attempted by pumping from groundwater sources.

Concerns associated with model predictions

Concerns and recommendations associated with the model predictions include those listed below. Additional concerns and recommendations could be identified if the model input files were available.

1. Assumptions regarding post-mining hydrogeological conditions

The groundwater model incorporates a specific and relatively detailed description of the hydrogeology at the site. This hydrogeology was necessary to match existing flow conditions. For example, among other characteristics of the site, the resistance to flow in the vertical direction needed to be 10 to 200,000 times greater than the resistance to flow in the horizontal direction in order to match existing flow conditions.

The same hydrogeologic characteristics used to describe the glacial deposits under existing conditions were also assumed for post-mining conditions. The modeling results also assume that large parts of the mined areas will be backfilled with materials that are compacted sufficiently to result in a hydraulic conductivity of 0.001 ft/day (3.5×10^{-7} cm/s). This is assumed to occur over layers that are currently 80 to 300 feet thick. There is essentially no possibility that hydraulic conductivities this low can be achieved through compaction of disturbed materials and there is very little possibility that the hydrogeologic parameters for the glacial deposits will not be impacted by the mining operations.

The impacts of changes to hydrogeological characteristics could be evaluated with the existing groundwater model. However, the sensitivity simulations described in the model report are based on a very narrow range of hydrogeologic parameters. For example, the hydraulic conductivity of the glacial deposits ranges over a factor of 2 and the storage values range over a factor of 1.5. The post-mining hydrogeologic properties could very

easily be different by several orders of magnitude, as compared to the pre-mining properties.

The existing groundwater model should be used to evaluate a much broader range of potential post-mining conditions. These evaluations should consider the effects of altered stratigraphy on base flow to streams and other groundwater characteristics. Input parameters should be based on realistic assumptions regarding the effects of mining disturbances on hydrogeological parameters.

2. Monthly and seasonal impacts to streamflow.

The estimated impacts and the sensitivity simulations presented in the groundwater modeling focus on annual values for baseflow. The monthly or seasonal impacts to baseflow will be much more sensitive to changes in hydrogeological parameters than the annual values reported in the modeling report and referenced in the PDSEIS. Sensitivity analyses related to base flow should incorporate monthly and seasonal evaluations. The seasonal range of baseflow under existing, mining, and post-mining conditions should be provided.

3. Uncertainty associated with boundary conditions and other aspects of the conceptual model.

A potentially-important parameter that was used in the predictive simulations but that was not used in model calibration is the conductance of drains. These conductance values control how much water flows into excavations associated with the mine. Because the model was not calibrated using data that describe flow into these excavations, there may be significant uncertainty associated with these parameters. The model should be used to evaluate the sensitivity to these parameters.

The sensitivity of other boundary conditions should also be evaluated, particularly with regard to the eastern model boundary. The approach that was apparently used to set this model boundary does not follow generally-accepted procedures.

4. Effects of model discretization

The glacial and alluvial deposits in the groundwater model are simulated using a single layer. Among other effects, this prevents vertical gradients from being included within these deposits (flow is only horizontal). The glacial and alluvial deposits should be discretized into additional layers to more reasonably simulate flow into excavations and impacts to streams. Documentation should be provided to show that the results are not sensitive to model discretization.

Importance of providing model input files

Model input files provide much more information than can be conveyed in a written report. These files allow the reviewer to test sensitivities and to fully evaluate model assumptions. Software used to develop and run groundwater models, including the software used in the Arcadis study, has become relatively standardized and most groundwater professionals have access to the models that are most often used for these types of applications.

It should be noted that providing model input files is a routine and standard practice in model reviews and is a part of professional standards for model documentation. Submittal of model datasets is required according to BLM's groundwater modeling guidance for mining activities (BLM, 2008). This guidance provides instructions for developing groundwater investigative studies in support of NEPA documents. The ASTM Standard Guide for Documenting a Ground-water Flow Model Application identifies information that is necessary so that a post-modeling audit can be adequately performed by a third party (ASTM, 2013). Model input files for the final calibration simulation and for predictive simulations are a part of that necessary information, according to the ASTM standards. Including data input files is also part of the "text-book" protocol for model documentation, as noted by Anderson and Woessner (1992): "*If you do not include the complete data input files in the report, you should archive them together with the results of calibration and sensitivity simulations. Directions on how to retrieve archived information should be included in the report*."

References:

Anderson, M.P. and W.W. Woessner, *Applied Groundwater Flow Modeling*, Academic Press, New York, 1992

Arcadis (2012) *Chuitna Coal Project; Groundwater Model Report*. August 2012. Highlands Ranch, Colorado.

ASTM D5718-13, *Standard Guide for Documenting a Groundwater Flow Model Application*, ASTM International, West Conshohocken, PA, 2013, www.astm.org.

Bureau of Land Management, Nevada State Office, 2008. Groundwater Modeling Guidance for Mining Activities. Instruction Memorandum No. NV-2008-035.